CLAIMS

1. A device comprising:

at least one input;

at least one output; and

means for selecting at least one of the at least one outputs, wherein the selection is dependent upon at least an orbital and/or spin angular momentum of at least one input electro-magnetic energy input or appearing at the at least one input, in use.

2. A device as claimed in claim 1, wherein there are provided a plurality of outputs.

3. A device as claimed in any preceding claim, wherein the at least one electro-magnetic energy comprises at least one electro-magnetic signal or beam.

4. A device as claimed in any preceding claim, wherein the electro-magnetic energy comprises a photonic energy comprising at least one photon.

5. A device as claimed in any preceding claim, wherein the means for selecting comprises means for directing or switching the at least one electro-magnetic energy to the selected at least one of the at least one outputs.

6. A device as claimed in any preceding claim, wherein the selected at least one of the at least one outputs comprises one of the at least one outputs.

7. A device as claimed in any preceding claim, wherein an output electro-magnetic energy, in use, appears at the selected at least one of the at least one outputs.

8. A device as claimed in claim 7, wherein the output electro-magnetic energy comprises at least part of the at least one electro-magnetic energy.

9. A device as claimed in any of claims 1 to 8, wherein the device is adapted for use at optical wavelengths.

10. A device as claimed in any of claims 1 to 8, wherein the device is adapted for use at or within a frequency range selected from one of: radio, millimetre wave or microwave.

11. A device as claimed in any preceding claim, wherein the device is adapted for use as a switching or multiplexing device.

12. A device as claimed in any of claims 1 to 11, wherein the electro-magnetic signal comprises at least one photon.

13. A device as claimed in any of claims 1 to 12, wherein the electro-magnetic signal comprises a beam.

14. An electro-magnetic device, such as an optical device, comprising:

at least one input;

a plurality of outputs;

means for directing at least one electro-magnetic signal or photon from the input to a selected of the outputs, the selection being dependent upon at least an orbital angular momentum of the/each at least one electro-magnetic signal or photon.

15. A device as claimed in claim 1 or claim 14, wherein the selection is dependent upon:

orbital angular momentum, l (OAM) solely;

orbital angular momentum and spin angular momentum, s (SAM) individually; or

orbital angular momentum and spin angular momentum combined, that is, total angular momentum, j.

16. An electro-magnetic device as claimed in claim 14, wherein the means for directing comprises at least one interferometer.

17. An electro-magnetic device as claimed in claim 16, wherein the or each interferometer includes means for inducing, in use, a rotation or invertion of an electro-magnetic mode of an electro-magnetic signal such as light mode of a photon in at least one arm of the interferometer.

18. An electro-magnetic device as claimed in claim 17, wherein the means for inducing a rotation comprises at least a first prism and a second prism.

19. An electro-magnetic device as claimed in claim 18, wherein at least one prism is positioned in each arm of the interferometer.

20. An electro-magnetic device as claimed in claim 18, wherein the first prism and second prism are positioned in one arm of the interferometer.

21. An electro-magnetic device as claimed in claim 19, wherein the at least first prism positioned in a first arm of the interferometer is rotated with respect to the at least second prism positioned in a second arm of the interferometer, the second prism being turned through an angle, α around a second optical path with respect to the orientation of the first prism in a first optical path.

22. An electro-magnetic device as claimed in any of claims 18 to 21, wherein the at least first prism and second prism introduce a phase shift in each passing photon.

23. An electro-magnetic device as claimed in any of claims 18 to 22, wherein each prism is a Dove prism.

24. An electro-magnetic device as claimed in any of claims 14 to 23, wherein the electro-magnetic device is an optical device comprising a one piece device in the form of a monolithic block.

25. An electro-magnetic device as claimed in any of claims 14 to 24, wherein the device includes means for rotation of a polarisation state (and hence spin angular momentum) of a photon or photons.

26. An electro-magnetic device as claimed in claim 25, wherein the means for rotation allows an output of the device to be determined by total angular momentum of a photon or photons not solely by orbital angular momentum.

27. An electro-magnetic device as claimed in either of claim 25 or 26, wherein the means for rotation comprise at least one half-wave retarder.

28. An electro-magnetic device as claimed in any of claims 14 to 16, or claims 17 to 27 when dependent upon claim 16, wherein the means for rotation are disposed within the or each interferometer.

29. An electro-magnetic device as claimed in any of claims 14 to 16, or claims 17 to 27 when dependent upon claim 16, wherein the means for rotation are disposed outwith the or each interferometer.

30. An optical device comprising:

an input;

a first beam splitting means;

a second beam splitting means;

a first reflective means;

a second reflective means;

a first prism;

a second prism; and

at least a first output and a second output,

wherein the first beam splitting means, the second beam splitting means, the first reflective means, and the second reflective means are arranged to form an interferometer arrangement, with the first prism disposed in a first arm of the interferometer arrangement and the second prism disposed in a second arm of the interferometer arrangement, the input leading to the first beam splitting

means and the at least first output and second output leading from the second beam splitting means, and wherein, in use, at least one photon is input into the device which determines or selects, based on an orbital angular momentum of the photon, the output to which the photon will pass.

31. An optical device as claimed in claim 30, wherein the first prism is rotated with respect to the second prism.

32. An optical device as claimed in either of claims 30 or 31, wherein the first prism and second prism introduce a phase shift in the or each passing photon.

33. An optical device as claimed in any of claims 30 to 32, wherein each prism is a Dove prism.

34. An optical device as claimed in any of claims 30 to 34, wherein the optical device comprises a one piece device in the form of a monolithic block.

35. An apparatus, such as an optical apparatus, comprising a plurality of cascaded devices according to claims 1 to 13, electro-magnetic devices according to claims 14 to 29, or optical devices according to claims 30 to 34, wherein the devices are arranged with an at least one output of one device communicating with another device.

36. An apparatus as claimed in claim 35, wherein the apparatus comprises a signal processing apparatus, such as optical signal processing apparatus.

37. An apparatus as claimed in either of claims 35 or 36, wherein a hologram is disposed between an output of the one optical device and an input of the another optical device.

38. An apparatus as claimed in clam 37, wherein, in use, the hologram acts to increase the orbital angular momentum of the or each photon which passes through the hologram.

39. A system, such as an optical system, including at least one device or apparatus, such as a optical device or optical apparatus, according to any of claims 1 to 38.

40. A system as claimed in claim 39, wherein where the device or apparatus is an optical device or apparatus, the device or apparatus provides the system with at least two possible output groups of output photons or states, the groups or states being selected by the device or apparatus depending on an orbital angular momentum feature of an input photon.

41. A system as claimed in either of claims 39 or 40, wherein the system further comprises a detector arrangement to detect a state of at least one output of the device or apparatus.

42. A system as claimed in any of claims 39 to 41, wherein the system is an optical communications system, such as a free space optical communication system.

43. A device as claimed in any of claims 1 to 13, an electro-magnetic device as claimed in any of claims 14 to 29, an optical device as claimed in any of claims 30 to 34, an apparatus as claimed in any of claims 35 to 38, or a system as claimed in any of claims 39 to 42, wherein the device/apparatus/system is adapted for use at a wavelength(s) selected from far infra-red to far ultra violet, such as near infra-red or visible, such as particularly 700nm to 3μm, and most particularly 1.3μm to 1.6μm.

44. A method of determining a feature of orbital angular momentum of an electro-magnetic energy such as a or each photon in an optical signal, the method comprising the steps of:

providing a device, such as an optical device comprising:

at least one input;

a plurality of outputs;

means for directing an electro-magnetic energy, such as at least one photon, from the input to a selected of the outputs, the selection being dependent upon an orbital angular momentum of the electro-magnetic energy, such as the/each at least one photon;

inputting the electro-magnetic energy into the device;

detecting a feature of the orbital angular momentum of the electro-magnetic energy;

directing the electro-magnetic energy to a selected one of a plurality of outputs, the selected output for the electro-magnetic energy being selected by the detected property of the electro-magnetic energy.

45. A method of communication or signal processing, such as optical communication or signal processing, the method comprising the steps of:

providing a detection system, such as an optical detection system, comprising at least one device, such as an optical device, and a detection means;

receiving at least one electro-magnetic energy or signal, such as at least one photon;

passing the at least one electro-magnetic energy through the detection system comprising at least one device so as to determine an orbital angular momentum of said at

least one electro-magnetic energy;

directing the at least electro-magnetic energy from the device to the detection means so as to identify said feature of orbital angular momentum of said electro-magnetic energy.

46. A method according to claim 46, wherein the method further comprises the steps of:

providing at least one transmission system, such as an optical transmission system; and

transmitting at least one electro-magnetic energy, such as at least one photon, to be received by said detection system.

47. A prism, the prism comprising:

an input;

an output; and

means for inverting a transverse cross-section of an optical beam or light mode transmitted through the prism without changing the polarisation state.

48. A prism as claimed in claim 47, wherein the input and the output are normal to an optical beam transmission axis.

49. A prism as claimed in either of claims 47 or 48, wherein the prism is formed of optical quality glass.

50. A prism comprising:

a first end face; and

a second end face, arranged substantially parallel to said first end face; and

a side face disposed between said first end face and said second end face, the side face being formed of two planar areas disposed in a inwardly orientated 'V' shape.

51. A prism as claimed in claim 50, wherein the prism acts, in use, to invert a transverse cross-section of an optical beam transmitted through the prism.

52. A prism as claimed in either of claims 50 or 51, wherein the prism is polarisation insensitive when an optical beam is input to the prism via an end face.

53. An optical device comprising two prisms according to claims 50 to 52.

54. A device as claimed in claim 53, wherein the device further comprises two beam splitters.

55. A device as claimed in either of claims 53 or 54, wherein the device is a block unit, with planar faces of

each component allowing each component to be arranged directly adjacent each other component.

56. A device as claimed in claim 55, wherein the block unit is a monolithic block.

57. An optical apparatus comprising a plurality of devices according to any of claims 53 to 55.

58. An optical communication system or signal processing system comprising at least one optical device according to any of claims 53 to 56 or optical apparatus according to claim 57.

59. A phased-array antenna adapted to generate or form an electro-magnetic energy, signal or beam with angular momentum.

60. Use of a phased-array antenna to generate or form an electro-magnetic energy, signal or beam with angular momentum.

61. A phased-array antenna adapted to detect angular momentum in or of an electro-magnetic energy, signal or beam.

62. Use of a phased-array antenna to detect angular momentum in or of an electro-magnetic energy, signal or beam.

63. A method of communication or signal processing using electro-magnetic energies, signals or beams, the method comprising: multiplexing using angular momentum of electro-magnetic beams by generation and sensing using phase differences in arrays of antenna.